Docker

Differences between virtualisation and containerisation

Feature	Virtualization 🖥️	Containerization 📦
Definition	Runs multiple OSes on a hypervisor.	Runs lightweight apps using shared OS.
Isolation	Each VM has its own OS.	Containers share the host OS.
Resource Usage	High (each VM includes a full OS).	Low (containers share the OS kernel).
Performance	Slower (full OS overhead).	Faster (directly runs on the host OS).
Startup Time	Minutes (loads entire OS).	Seconds (only starts the app).
Portability	Limited (large VM images).	Highly portable (runs anywhere).
Use Case	Running multiple OS environments.	Microservices, cloud apps, CI/CD.
Tools	VMware, VirtualBox, Hyper-V.	Docker, Kubernetes, Podman.

What's Included in a Container vs. Virtual Machine?

Component	Container 📦	Virtual Machine 🖥️
Kernel	Shared with the host OS	Separate for each VM
Operating System	Not included (uses host OS)	Full OS (Windows, Linux, etc.)
Libraries & Dependencies	Included for the app only	Included with the full OS
Application	Runs inside the container	Runs inside the VM
Hypervisor	❌ Not needed	☑ Required to manage VMs

Benefits of Each (Virtual Machines vs. Containers)

🖥️ Virtual Machines (VMs) Benefits
☑ Full Isolation:

Each VM has its own OS, providing strong security. Ideal for running different OSes on one machine (e.g., Windows and Linux).
☑ Better for Legacy Apps:

Great for apps that require a specific OS or system dependencies.
☑ Stable & Reliable:

Works well in traditional enterprise environments.
☑ Supports GUI-based Applications:

Unlike containers, VMs can run full desktop environments.
📦 Container Benefits

☑ Lightweight & Fast:

Starts in seconds (no OS boot required).
Uses fewer resources since multiple containers share the same OS.
☑ Highly Portable:

"Build once, run anywhere" (works the same across different environments).
☑ Better for Microservices & Cloud:

Works well for DevOps, CI/CD, and modern cloud applications.
☑ Scalability & Efficiency:
Uses less memory and CPU compared to VMs, allowing more apps per server.

Microservices

What are they?

Microservices are a software architecture style where an application is broken down into small, independent services that communicate with each other. Each microservice:

✔ Handles a specific function (e.g., authentication, payment, inventory).
✔ Communicates via APIs (usually REST or gRPC).
✔ Can be developed, deployed, and scaled independently.

How Are Microservices Made Possible?

1. Containers & Orchestration
    - Docker: Packages microservices into isolated, portable containers.
    - Kubernetes: Manages, scales, and orchestrates microservices across multiple servers.
2. API Communication
    - RESTful APIs or gRPC: Allows microservices to talk to each other.
    - Message Brokers (Kafka, RabbitMQ): Helps in asynchronous communication.
3. DevOps & CI/CD
    - Continuous Integration/Continuous Deployment (CI/CD): Automates testing and deployment.
    - Infrastructure as Code (IaC) (Terraform, Ansible): Automates cloud/server provisioning.
4. Cloud & Scalability
    - Cloud Services (AWS, Azure, GCP): Provides managed services to deploy microservices.
    - Service Discovery (Eureka, Consul): Helps services locate each other dynamically.

Docker- What is it

What is it?

Docker is a containerization platform that allows developers to package applications and their dependencies into lightweight, portable containers. These containers can run on any environment (local, cloud, or on-premise) without compatibility issues.

◇ Key Features:
☑ Portability – "Write once, run anywhere"
☑ Lightweight – Uses fewer resources than virtual machines

☑ Fast Deployment – Containers start in seconds
☑ Scalability – Easily scale applications across multiple servers

Alternatives

- Podman
- LXC (Linux Containers)
- Singularity

Success story: Netflix

Netflix needed to:

Scale services rapidly across different cloud environments.
Improve developer productivity.
Reduce deployment time for thousands of microservices.
◇ The Docker Solution:
☑ Microservices with Docker: Netflix broke down its monolithic app into microservices, each running in Docker containers.
☑ Consistent Environment: Developers could create identical local environments to production using Docker.
☑ Scalability with Kubernetes: Containers were managed and scaled dynamically.

Task: Run and pull your first image

- Command to see docker images already on your local machine: `docker image ls`
- Run command 'hello world' is: `docker run hello-world`
- First run: Docker checks if the image exists on your local machine.
  Since the image is missing, Docker pulls it from Docker Hub.
- Second run: Docker checks if the hello-world image is already on your machine. Since it's already downloaded, Docker does not pull it again.

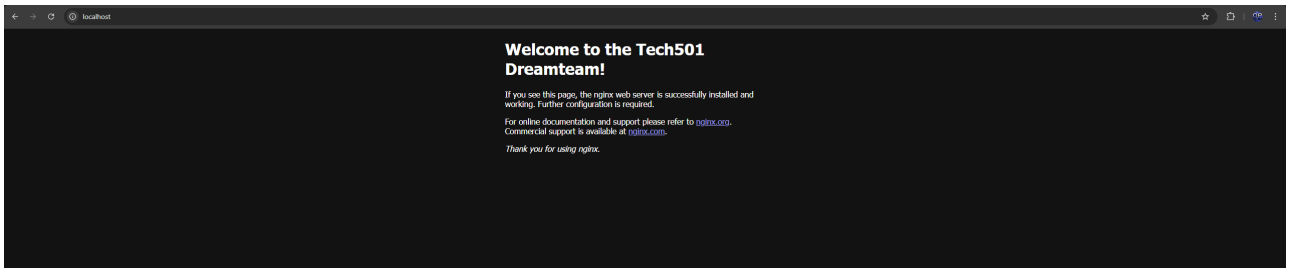
Task: Run Nginx web server in a Docker container

`docker pull nginx:latest` `docker run -d -p 80:80 --name my-nginx nginx` - Creates the nginx and specifying the port for it to run on `docker start my-nginx`- to start nginx `docker ps` - to check if its running `docker ps -a`- to see all the containers `http://localhost` - to check if its working `docker stop my-nginx` - to stop the container running

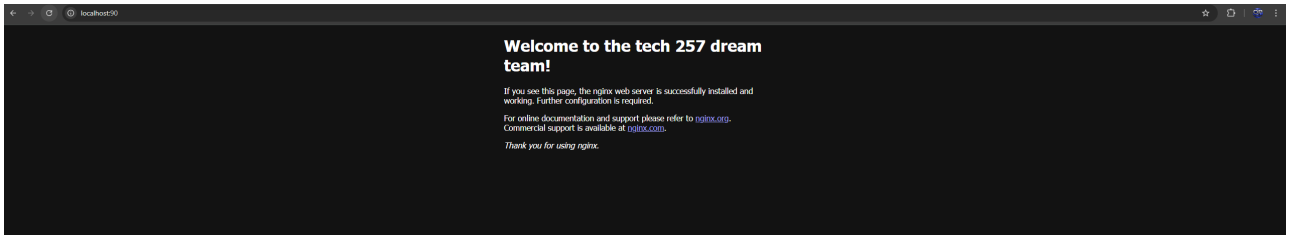
Task: Remove a container

- `docker rm my-nginx` - To remove the nginx container. Doing whilst running will give you an error of: `Error response from daemon: cannot remove container "/my-nginx": container is running: stop the container before removing or force remove`
- `docker exec -it <container_name_or_id> /bin/bash`- the command to access the shell of a container, for my nginx it would be `docker exec -it my-nginx /bin/bash` - used windows powershell as it didn't work in git bash
- `apt-get update apt-get install sudo` - used to install sudo so we can run the update and upgrade commands
- `cd /usr/share/nginx/html` - command to get to the part where the index file is for the nginx.

- `apt-get update apt-get install nano` - To install nano command. `nano index.html` - to go into the index file to make the change



Task: Run a differetn container on a different port

- Using the command: `docker run -d -p 80:80 --name dreamteam-nginx daraymonsta/nginx-257:dreamteam` - gives an error can't expose it to port 80 as it is already in use.
- `docker rm dreamteam-nginx`- to remove the container]
- `docker run -d -p 90:80 --name dreamteam-nginx daraymonsta/nginx-257:dreamteam` - command to put it on port 90, use http://localhost:90 to see it on port 90
- 

Task: Push host-custom-static-webpage container image to Docker Hub

Step 1: Get the container id

- Get the container id first by running the command `docker ps`

Step 2: Commit the file

- Using this command `docker commit <container_id> yourdockerhubusername/custom-nginx`

Step 3: Login your docker account in the terminal

- `docker login`- will tell you match the authorisation code from the terminal to the one in the browser

Step 4: Push the image to your docker account

- `docker push myusername/custom-nginx:latest` -pushes it to your docker account

Docker command that runs the container which uses the pushed container image

- docker run -d -p 80:80 --name my-nginx-container yourdockerhubusername/custom-nginx:latest

Task: Automate docker image creation using a Dockerfile

step 1 - create docker file

Dockerfile > ...

```
FROM nginx:1.21.6

WORKDIR /usr/share/nginx/html
COPY index.html .
# Expose port 80 for the Nginx web server
EXPOSE 80

CMD ["nginx", "-g", "daemon off;"]
```

step 2 - create an index.html file

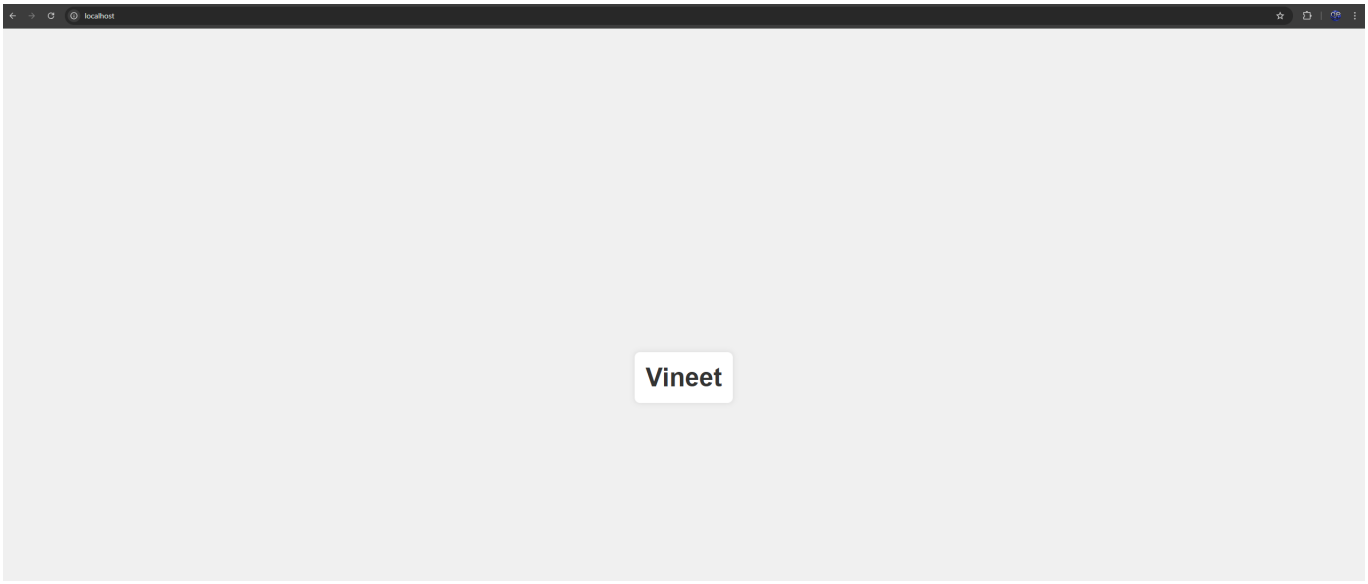
index.html > html

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Vineet's Page</title>
    <style>
        body {
            font-family: Arial, sans-serif;
            background-color: #f0f0f0;
            display: flex;
            justify-content: center;
            align-items: center;
            height: 100vh;
            margin: 0;
        }
        .container {
            text-align: center;
            padding: 20px;
            background-color: white;
            border-radius: 10px;
            box-shadow: 0 0 10px rgba(0,0,0,0.1);
        }
        h1 {
            color: #333;
```

Step 3

- `docker build -t tech501-mod-nginx-dockerfile .` - creates the image
- `docker run -d -p 80:80 --name my-nginx-container2 sha2` - creates the container
- `docker rmi <image-id>` to remove the image off your local
- `docker run --pull always -d -p 80:80 --name my-nginx-container yourdockerhubusername/nginx-custom:latest`

Step 4: Run the localhost in the browser

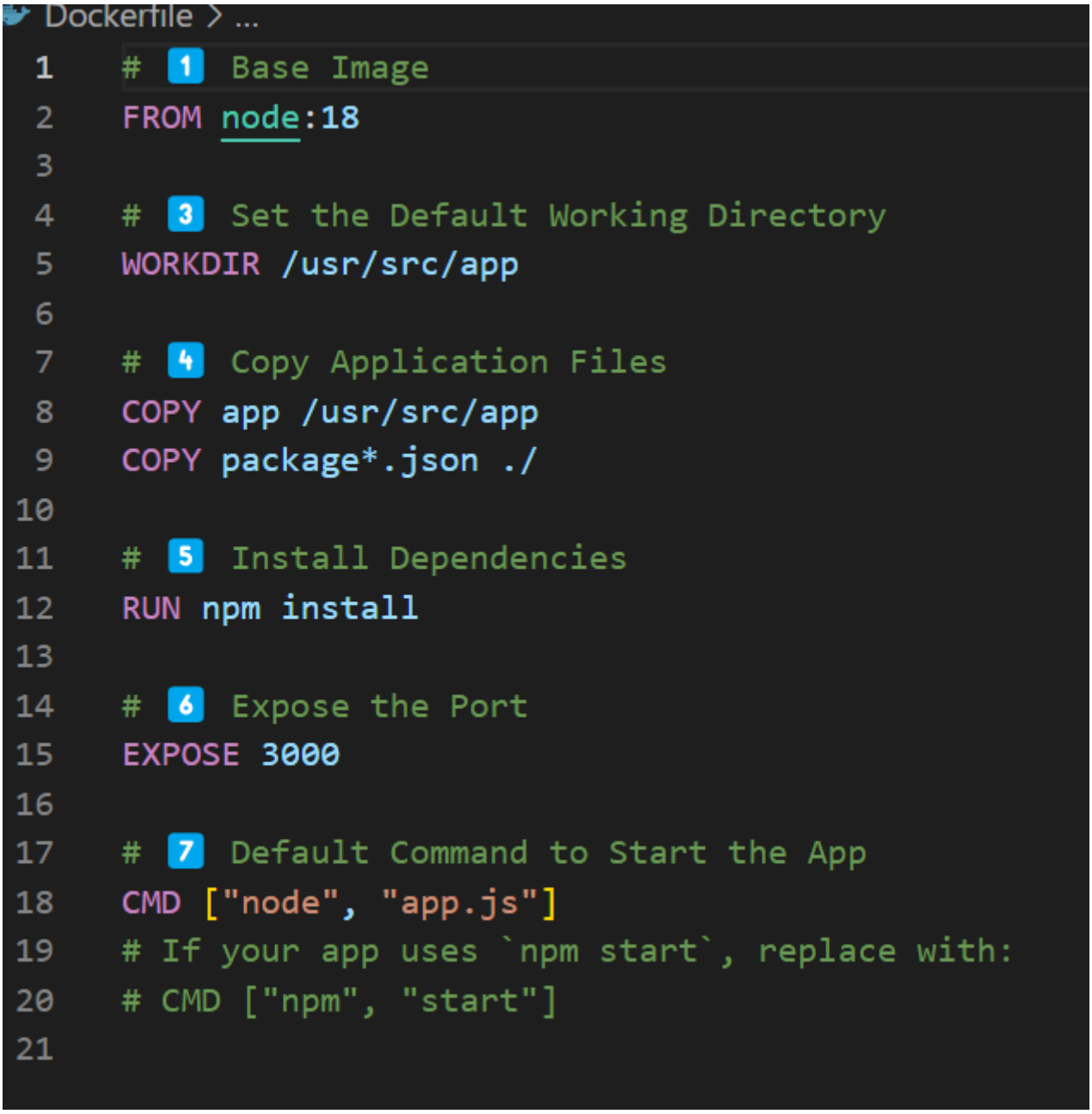


Task: Run Sparta test app in a docker container

Step 1: Create a new repo and folder

Step 2: Move the app folder into the new folder

Step 3: Create a new Dockerfile in the folder

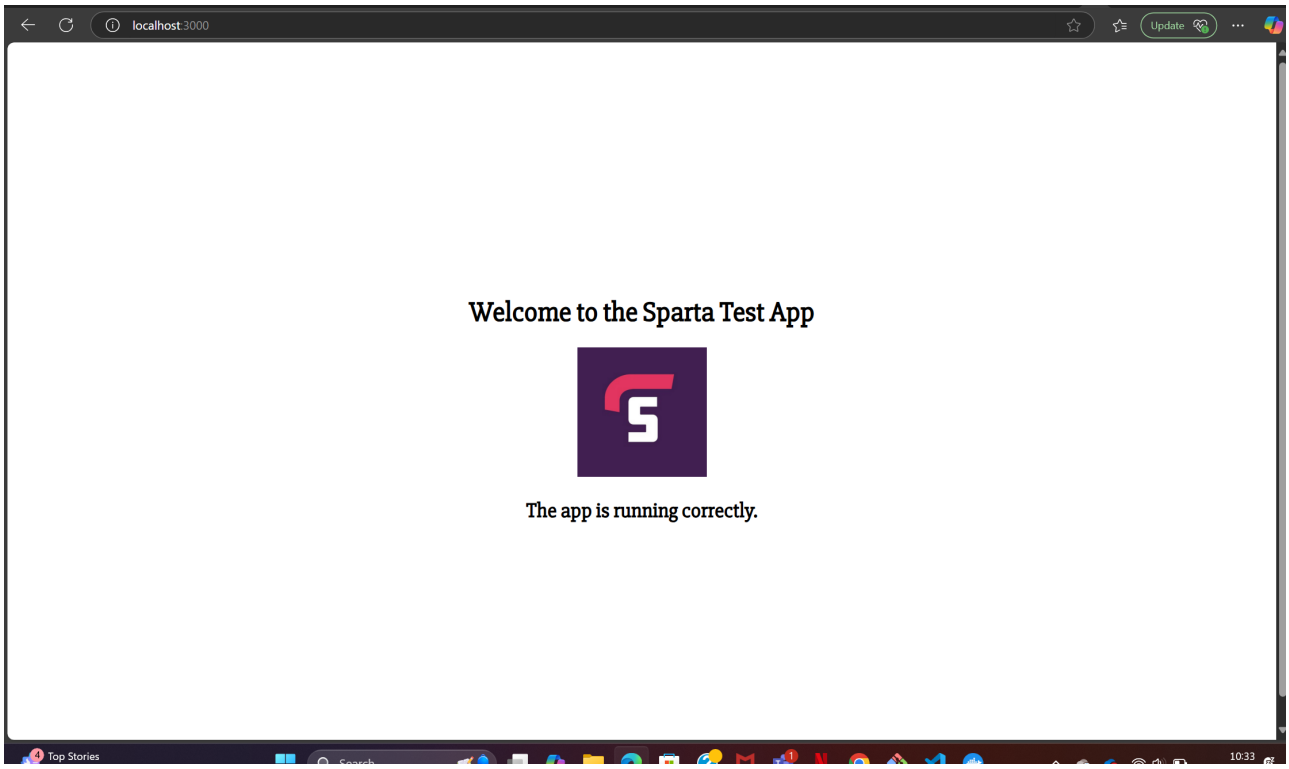


Step 4: Build the docker image

- `docker build -t yourdockerhubusername/my-app:latest .` - this command will build the docker image

Step 5: Run the docker container

- `docker run -d -p 3000:3000 --name my-running-app yourdockerhubusername/my-app:latest`- this command will run the docker container



Step 6: Push the image to docker hub

- Login into docker account
- Use this command to push to docker account `docker push yourdockerhubusername/my-app:latest`

Step 6: Force docker to pull a fresh image from docker hub

- First force the image to be removed from local
- `docker run --pull always -d -p 3000:3000 --name my-running-app yourdockerhubusername/my-app:latest`

Task: Research Docker compose

Why use it?

- Docker Compose is useful when you need to define and manage multi-container Docker applications. Instead of manually running multiple docker run commands, Compose allows you to define your entire application stack in a simple YAML file (docker-compose.yml). Here's why you should use Docker Compose:
  - Easy Configuration and Version Control
  - Simplifies Multi-Container Management
  - Consistency Across Environments
  - Dependency Management

How to use it?

What to install?

- You need to install docker compose

How to store the compose file?

- A docker-compose.yml file should be stored in your project directory, typically at the root.

Command to manage your application

- Start the Application (Without Detached Mode) = `docker compose up`
- Start the Application (In Detached Mode) = `docker compose up -d`
- The difference between with/without detached node: Detached (-d) -Runs in the background, keeps running even if you close the terminal. Foreground (default) Shows logs in the terminal, stops when you press CTRL + C.
- Stop the application: `docker compose down` or if you want to stop without removing the containers: `docker compose stop`
- Run application in detached mode= `docker compose up -d`
- Check Services Running with Docker Compose= `docker compose ps`
- View logs in real time= `docker compose logs -f`
- View docker compose images= `docker compose images`

Task: Use Docker compose to run app and database containers

Step 1: Pull the docker MongoDB image

- `docker pull mongo:6.0`
- Run it as a container `docker run -d \ --name my-mongodb \ -p 27017:27017 \ -v mongo-data:/data/db \ -e MONGO_INITDB_ROOT_USERNAME=admin \ -e MONGO_INITDB_ROOT_PASSWORD=password \ mongo:6.0`

Step 2: Create a docker-compose.yml file

- `touch docker-compose.yml`
- `nano docker-compose.yml`

docker-compose.yml

```yaml
version: "3.8"

services:
  app:
    image: vineetsethi1/my-app:latest  # Replace with your actual image
    container_name: my-app
    restart: always
    command: sh -c "node seeds/seed.js && npm start"
    networks:
      - app-network
    ports:
      - "3000:3000"
    depends_on:
      - mongodb
    environment:
      DB_HOST: "mongodb://mongodb:27017/mydatabase"  # Connect app to MongoDB
      #SEED_MONGODB: "true"  # Seed MongoDB with sample data

  mongodb:
    image: mongo:6.0
    container_name: my-mongodb
    restart: always
    networks:
      - app-network
    ports:
      - "27017:27017"

networks:
  app-network:
    driver: bridge
```

Step 3: Start the containers

- `docker compose up -d`

Step 4: SSH into the app container

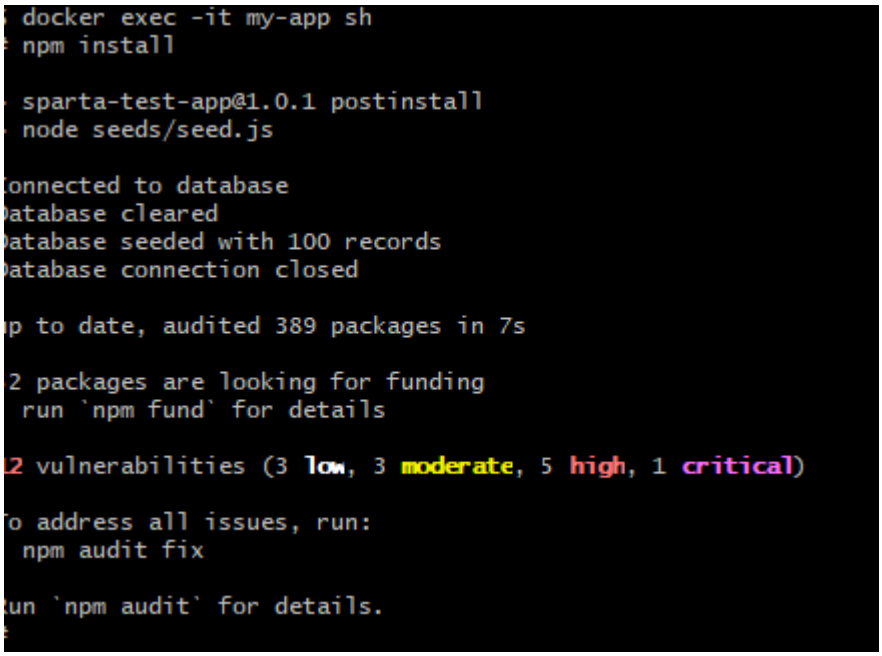
- `docker exec -it my-app sh`
- Create the DB_HOST env variable

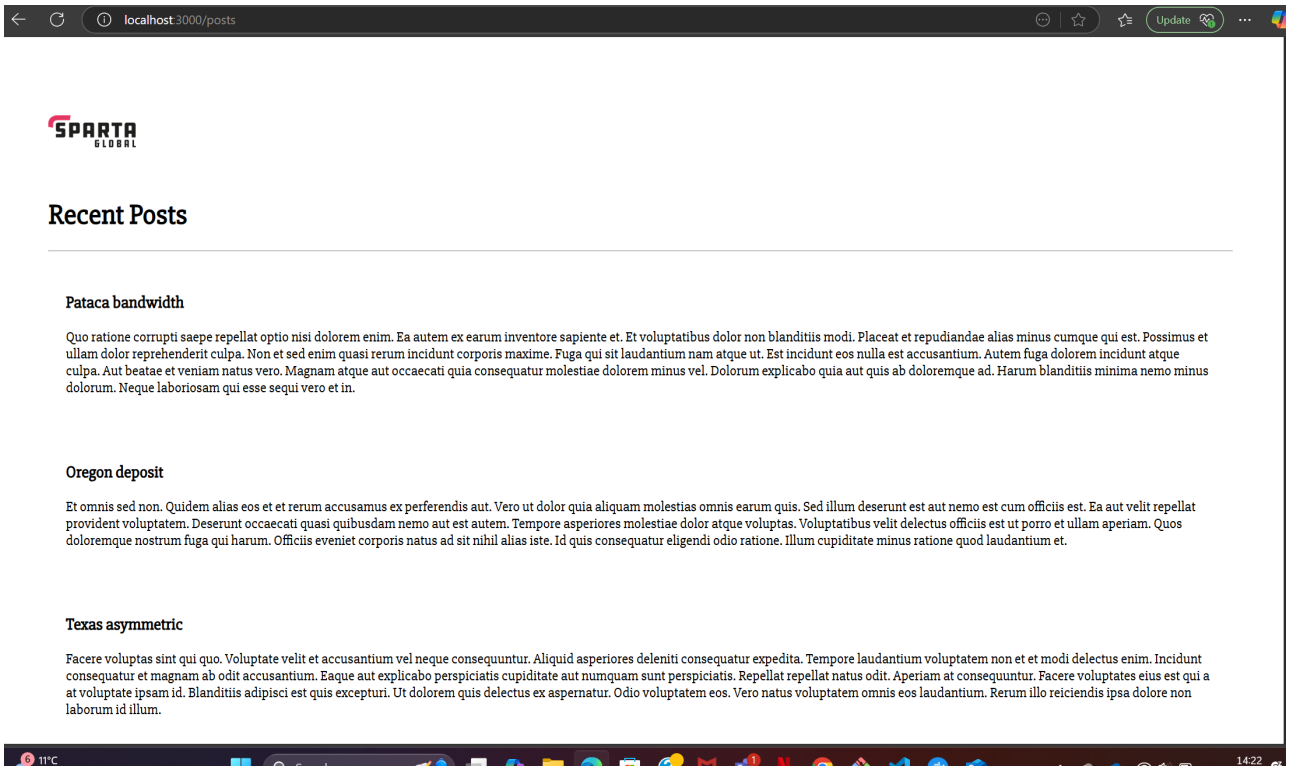
Step 5: Make sure to keep the app and db in the same network

- This can be done in the docker compose file by specifying network in both the app and db code

Step 6: You can either manually seed the database or automatically

- Manual:
    - Go into the app cotainer and run `npm install`





- Automatic:
  - Go into the compose file and a command `command: sh -c "node seeds/seed.js && npm start"`